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ABSTRACT

Concepts, propositions, proposition sets, and process patterns are discussed as elements of a model of language-related basic thinking skills. The term "concept" is defined and illustrated, and a model of concept attainment is briefly described. Illustrations are offered for a set of 430 basic concept clusters intended for use as a concept curriculum in kindergarten through sixth grade. In addition, the term "proposition" is defined and illustrated. Elementary and secondary school course content is perceived as consisting of sets of propositions. Five basic ways propositions can be related to one another are specified, and a few of these relationships are exemplified. Propositions are thought to be related referentially, temporally, causally, additively, and contrastively. It is argued that the extent to which students recognize the five basic types of relationships and their subtypes governs their ability to process information. The five basic types of relationships among propositions are also seen as being used to link large blocks of propositions into proposition sets. Processes considered fundamental to education (input, organization, and output) are defined, and two basic organizational processes (generalizing and evaluating) are illustrated. Concluding sections hierarchically order the elements of the model of thinking skills and point out instructional implications. (RH)

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TOWARD A MODEL OF HIGHER ORDER THINKING SKILLS

by

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What are the basic thinking skills pertinent to education? In this manuscript, I will attempt to briefly answer that question in a fashion that is useful to elementary and secondary school teachers. I will do this by first proposing a model of how the mind stores and uses information. This model will then be translated into a hierarchy of thinking skills. I should stress that I am presenting only an overview of that hierarchy. A detailed description of the hierarchy and K-12 teaching techniques is contained in Basic Concepts and Higher Order Thinking Skills: A Linguistic Perspective(R. Marzano, Mid-continent Regional Educational Laboratory, 1983) We must first start with a model of how information is stored in long term memory.

To begin, let us hypothesize what might be in an individual's long term memory at any point in time. Let's assume we could stop ourselves in the act of "thinking" and look inside the mind. What we would find stored as connections among neurons (or more correctly as dispositions for neurons to pass an electrical charge) would be our representation of the outside world. That representation could be categorized into two basic types of information: episodic information and semantic information. Episodic information is made up primarily of our "images" and "sensations" associated with events or episodes in our life. For example, if you think back to some pleasant event, you will probably recall "pictures" of that event and in some cases sensations associated with the event. Semantic information is made up of concepts and linguistic information. Semantic information is usually observable as the "little voice" in our memory that seems to narrate our remembrances. To illustrate, recall an event from your past. You will probably immediately notice the "pictures" that accompany the event. If you continue observing

yourself in the act of remembering, you will also notice a narrative voice. That voice is expressing the semantic information you have stored about the event.

It is impossible to discuss semantic information without also discussing language because language is the way we represent semantic information in long term memory. Language, then, plays a key role in an individual's ability to process information. Language is also the primary vehicle used to transmit information in the schools. That is, the vast majority of the information students are expected to comprehend and master in school is presented in linguistic form. For example, students must read books and comprehend what is read; teachers give information orally; and students are asked to show they know information by responding orally or in writing. Because of the importance of semantic information presented linguistically, the model of thinking skills I will describe here is observable and expressable in terms of language. In developing the model I will discuss: 1) concepts, 2) propositions, 3) proposition sets and 4) process patterns.

CONCEPTS

A concept is the basic unit of semantic or linguistic information stored in long term memory. Relative to language, a concept is the socially accepted meaning of one or more words which express the concept. In general, there is close to a one to one correspondence between the words in a language and the concepts expressed in that language. To illustrate, consider the following:

Young boys like sports.

Here there are four concepts expressed by the words young, boys, like and sports. These words are "labels" for the concepts youngness, boyness, liking and sports. If we were to identify all of the words used in school textbooks, we would, in effect, be identifying the concepts that are presented to students in the form of printed information. There have been many attempts to do this. For the most part, these attempts have resulted in lists of words with the grade level of each word identified. These lists provide interesting, but not very useful information in an instructional sense. That is, a graded list of words/concepts provides no information about how best to teach and reinforce those concepts. For the answer to the question of how to teach concepts, we must make some generalizations about how students learn new concepts.

The specifics of how concepts are learned is a matter of debate. There is, however, some agreement as to the general process of concept attainment. To illustrate, assume that a student is presented with the word domicile. He/she has never encountered this concept before. The process of integrating this concept into the student's store of existing concepts is one of identifying how the new concept is similar to and different from concepts the student already knows. For example, when learning the concept domicile, the student might first learn that the concepts house, home and apartment are also examples of or are similar to the concept domicile. The student might then learn that the concepts factory, store, shed and barn are not examples of the concept domicile but are similar in some dimensions. Over time and after some experience with the new concept, the student will eventually find a place for it among the old concepts. When this happens, the student is said to know or understand the concept domicile.

If this model of concept attainment is accurate, it makes sense that educators can facilitate the concept attainment process for students by identifying "clusters" of related concepts presented in the schools. As part of this model, 430 basic concept "clusters" were identified using the 7,000 most frequently used words in elementary school textbooks. To illustrate a basic concept cluster, consider the following:

Grabbing/Holding Actions

	Concept	Grade Level	Syntactic Form
1.	hold	1	Noun - verb
	catch	1	Noun - verb
	squeeze	3	Noun - verb
	grab	3	Verb
	grip	4	Noun - verb
	clutch	4	Verb
	clasp	5	Noun - verb
	wring	5	Verb
	clench	6	Verb
2.	pick	2	Verb
	pinch	4	Noun - verb
	pluck	6	Verb
	nip	6	Noun - verb
3.	hug	3	Noun - verb
	wrap	3	Verb
	cling	4	Verb
	nuzzle	4	Verb
	embrace	6	Noun - verb
	snuggle	6	Verb

The cluster name is "grabbing/holding actions." Within the cluster there are three unnamed sets of related concepts. These represent concepts with closer semantic ties than those represented by the more general cluster name. Concepts within the subcluster and the main cluster are meant to be introduced to students as sets. That is, when introducing one concept to students, the other concepts within the cluster or subcluster may also be introduced. Of course, this practice should greatly escalate the speed with which students are exposed to the basic concepts found in elementary school textbooks.

The 430 basic concept clusters are intended as a K-6 concept curriculum and provide the building blocks upon which the concepts learned at the secondary level are developed.

PROPOSITIONS

Concepts are not the only form in which semantic information is stored. Another unit of storage is the "proposition." Propositions are concepts grouped together in such a way as to convey new information. To illustrate, consider the following:

Columbus discovered America in 1492.

Here we have four concepts: Columbus, discovered, America and 1492. Each of these concepts has meaning in isolation; however, putting them together in the fashion above conveys information that is more than or greater than the individual parts. Such a grouping of concepts is called a "proposition." For the purposes of this paper, it is not important to understand the exact definition of a proposition. It is probably easiest to say that a proposition is roughly equal to the linguistic information presented in a clause.

The content of courses taught at the elementary and secondary school levels can be described as sets of propositions. For example, if a student understood the five propositions below, we would say that the student knew something about triangles.

Proposition 1: Triangles have three sides.

Proposition 2: The sides are made of straight lines.

Proposition 3: Triangles have three angles.

Proposition 4: The angles add up to 180 degrees.

Proposition 5: There are many different types of triangles.

Again the sum total of what is said in these propositions is greater than the information contained in each proposition considered in isolation. That is, these five propositions represent a <u>set</u>; they are tied together or related in some fashion. For a student to comprehend the totality of the information that is conveyed by these propositions, the student must be able to understand how they are related.

There are five basic ways that propositions can be related to one another: 1) by reference, 2) temporally, 3) causally, 4) additively and 5) contrastively. We will briefly consider a few of those relationships here.

Propositions are related via reference when a concept in one proposition is repeated or referred to in another. To illustrate, consider the two propositions below:

a) Bill likes cars

b) They are his favorite pastime

<u>They</u> in <u>b</u> "refers" to <u>cars</u> in <u>a</u>; <u>his</u> in <u>b</u> "refers" to <u>Bill</u> in <u>a</u>. Reference is the most frequently used method of connecting propositions. Time, cause, addition and contrast relationships are also frequently used. They are exemplified below:

<u>Time</u>:

Bill got up

Then he ate breakfast

Time Relationship

<u>Cause</u>:

Bill got up

because his mother called him

Cause Relationship

<u>Addition</u>:

Bill is handsome

and he is smart

Addition Relationship

<u>Contrast</u>:

Bill is handsome

but he is not conceited

Contrast Relationship

There are many subtypes of reference, time, cause, addition and contrast relationships. They are listed but not exemplified below:

Reference:

1) same word reference
2) synonym reference
3) pronoun reference
4) metaphoric reference
5) related concept reference
6) whole idea reference
7) deleted subject reference

Time:

1) subsequent action
2) prior action
3) concurrent action

Cause:

1) direct cause
2) result
3) reason
4) inference
5) condition

Addition:

1) equality
2) restatement
3) example
4) summation

Contrast:

1) antithesis
2) alternative
3) comparison
4) concession

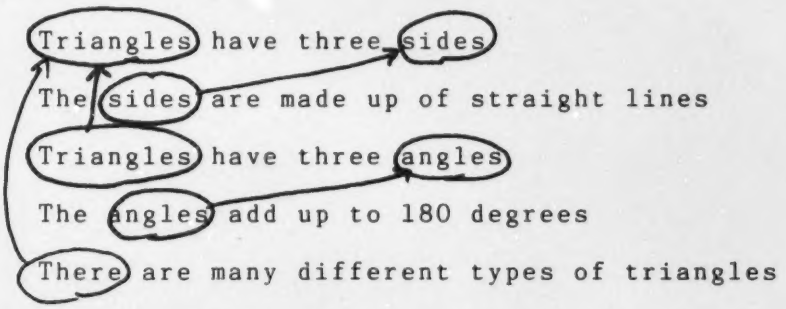
The extent to which students recognize the five basic types of relationships and their subtypes in information presented to them linguistically governs their ability to process that information. What occurs when a student stores a set of propositions in long term memory is that the student connects the propositions via reference, time, cause, addition and contrast. These connections give the student access to any of a number of proposition via any one proposition. That is, semantic information in long term memory can be characterized

as a group of propositions which are related to one another. Some of these propositions are grouped together not just in pairs but in large sets.

PROPOSITION SETS

The five basic types of relationships among propositions are used to tie together large blocks of propositions which I call proposition sets. Proposition sets have distinct patterns of relationships; that is, they use the five basic types of relationships in distinct ways. There are five types of patterns commonly used to connect proposition sets: 1) concept patterns, 2) similarity patterns, 3) dissimilarity patterns, 4) sequence patterns and 5) process patterns. To illustrate, we will briefly consider a few:

Concept patterns use reference as the primary method of connecting propositions. To illustrate, reconsider the set of proposition which was introduced earlier about triangles:


Triangles have three sides
The sides are made up of straight lines
Triangles have three angles
The angles add up to 180 degrees
There are many different types of triangles

When a student identifies a concept pattern in a set of propositions, he/she is actually identifying characteristics of the concepts within the proposition set. This is more dramatically illustrated if we rearrange the information presented in the set above and exclude some words:

Triangles

-- have three sides

-- made of straight lines

-- have three angles

-- sum to 180 degrees

-- many different types

Here there are three pieces of information or three characteristics presented about the concept <u>triangles</u>: 1) they have three sides, 2) they have three angles and 3) there are many

different types. Also, one characteristic is stated about the related concept sides and one piece of information about the related concept angles. The identification of concept patterns among propositions builds a student's knowledge of the concepts within the set. Obviously this is a key factor in learning.

Sequence and similarity patterns are also quite important in terms of learning new information although they are not as common as concept patterns. They are exemplified below:

Sequence Pattern:

Bill got up

Then he ate breakfast — Time Relationship

Afterwards he went to school — Time Relationship

After that he played baseball — Time Relationship

Similarity Pattern:

There were many causes to the war

The economy was bad

The poor were getting poorer — Addition Relationship

The factories were closing — Addition Relationship

Also, they dropped a bomb on us — Addition Relationship

Process patterns are perhaps the most infrequently expressed patterns in oral and written language. The purpose of a process pattern is to describe a set of events which lead to some outcome. For example, below is a set of propositions which describe the process of baking a cake:

To bake a cake . . .

You must first take out the pots and pans

Then you must get the ingredients . . .

Etc.

Process patterns can be very sophisticated or very simple. For example, some people have process patterns for how to split an atom; they also have process patterns for how to open a door. As we shall see, process patterns form the key to a student's ability to learn.

PROCESS PATTERNS

Process patterns are the driving force behind human behavior. That is, human beings have a process pattern for virtually everything they do. Even something as simple as raising your hand has a process pattern associated with it. Many of the process patterns that relate to physical movement we are born with. However, the process patterns for such simple tasks as opening a door or changing a tire are learned. In general, we learn process patterns by experience. That is, we observe other people doing things and then copy their patterns, or we develop our own process pattern via trial and error. There are many process patterns relative to education that are never formally taught in the school. In a sense, educators unwittingly expect students to learn these patterns on their own. Usually it is the brighter students who quickly identify and integrate the important educational patterns into their existing store of patterns. The less educationally adept students might go for years without ever identifying or integrating the important educational process patterns. It seems evident, then, that the extent to which we can identify the process patterns basic to education will be a major factor in our ability to educate students efficiently. What are these important education patterns?

To answer this question we must expand our model of the mind and view it as an information processing system. For this purpose it is best to represent the mind as a mechanism which receives information (input): processes that information (organization) and sometimes does something (output) as a result of that input and organization.

We say we "learn" something when the input information is new to us or when we organize old information in a new way. We can say, then, that our ability to learn is a function of our ability to: 1) receive input information, 2) organize that input information and 3) perform output activities based on the newly organized information. Our original question about the processes relevant to education now becomes: "What are the input, organizational and output processes fundamental to education?" A list of such processes is presented below:

Input Processes:

a) Listening
b) Reading
c) Content Specific Input Processes

Organizational Processes:

d) Generalizing
e) Summarizing
f) Categorizing
g) Evaluating
h) Inferring

Output Processes:

i) Remembering
j) Presenting Information Orally
k) Presenting Information in Written Form
l) Problem Solving
m) Content Specific Output Processes

Using the terminology presented thus far (eg. concepts, propositions, relationships, etc.) we can fairly precisely define each of these processes:

a) Listening: The process of integrating and storing information that is presented in oral language form.

b) Reading: The process of integrating and storing information that is presented in written language form.

c) Content Specific Input Process: Input processes specific to certain content areas. For example, "reading a bar graph" might be an input process specific to mathematics.

d) Generalizing: The process of concluding: 1) that a set of propositions which are related to one proposition are also related to another proposition or 2) that a set of characteristics which are related to one concept are also related to another concept.

e) Summarizing: The process of concluding that one proposition is related to a set of others -- specifically that one proposition has an additive or contrastive relationship to a set of others.

f) Categorizing: The process of concluding that the characteristics of one concept are similar to the characteristics of another concept or group of concepts.

g) Evaluating: The process of comparing input propositions or concepts with stored propositions or concepts and judging the accuracy or value of the input concepts/propositions relative to the stored concepts/propositions.

h) Inferring: The process of concluding that a concept or proposition exists when that concept or proposition is not explicitly stated in the input information.

i) Remembering: The process of retrieving specific, stored concepts (and their related characteristics) or specific propositions (and their related propositions) based on some input information.

j) Presenting Information Orally: The process of representing stored information in oral language form.

k) Presenting Information in Written Form: The process of representing stored information in written language form.

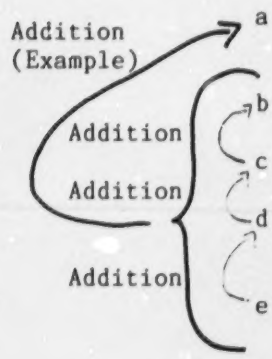
l) Problem Solving: The process of identifying a specific unknown concept, characteristic, proposition or proposition set given a set of input propositions.

m) Content Specific Output Processes: Output processes specific to certain content areas. For example, setting up an experiment might be an output process specific to a science class.

I should make it clear here that this categorization of processes is an oversimplification of the processes actually involved. What I have done here for descriptive and organizational purposes is treat input, organizational and output processes as though they occurred in isolation. The truth of the matter is that all of the processes described above probably have input, organizational and output phases of their own. For example, the process of reading clearly has all three processes involved. What I have actually described above are macro-processes which are composed of a series of subprocesses. Given the purpose to which this model of cognition is devoted, namely the instruction and reinforcement of thinking skills, this aggregation of subprocesses into more general processes is warranted.

For illustrative purposes, let us consider in more detail two of the basic organizational processes: generalizing and evaluating.

Generalizing is the process of concluding: 1) that a set of propositions which are related to one proposition are also related to another proposition or ... 2) that a set of characteristics which are related to one concept are related to another concept. To illustrate the process of generalizing, consider the following set of propositions:



a) The war in Europe started as a result of many factors.

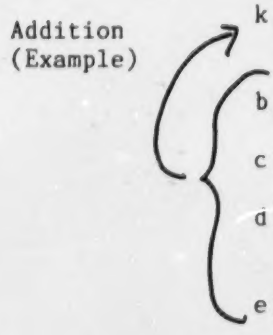
b) There was widespread unemployment.

c) The national currency had lost its value.

d) There were two distinct classes -- the rich and the poor.

e) There were a number of hostile bordering countries.

Propositions b, c, d and e all have additive relationships with proposition a. They are examples of a. (Example relationships are a subtype of addition relationships.) The process of generalizing would be one in which propositions b, c, d and e were assumed to have an example relationship with some other proposition:



k) Most wars are started as a result of the following factors.

b) There is widespread unemployment.

c) Currency loses its value.

d) There are two distinct classes of people -- the rich and the poor.

e) There are a number of hostile countries bordering.

Another way of saying this is that generalizing is the process of substituting one generalization for another. In the first example, proposition a was a generalization to b, c, d and e. In the second example, proposition k was substituted as the generalization.

The process of generalizing also occurs with concepts and their related characteristics. For example, consider the following set of propositions:

a) Chicago is a large city

b) It has a high density population

c) It is highly industrial

d) It is hot in the summer and cold in the winter

e) It has an excellent public transportation system

Here we have a strong conceptual pattern of relationships. Propositions b, c, d and e state characteristics of the concept Chicago. A form of generalizing would be to attach propositions b, c, d and e to the concept New York or the concept all large cities.

Evaluating is the process of comparing input propositions or concepts with stored propositions or concepts and judging the accuracy or value of the input concepts/ propositions. This definition illustrates that there are two distinct types of evaluating: 1) judging accuracy and 2) judging value.

To illustrate the process of judging accuracy, assume that you are given the following input proposition:

In 1495 Columbus sailed across the Atlantic

To judge the accuracy of this proposition, you would search your store of information in long term memory for a proposition similar to the one above. When found, you would compare the input proposition with the stored proposition.

Input Prop: In 1495 Columbus sailed across the Atlantic

Stored Prop: In 1492 Columbus sailed across the Atlantic

The extent to which the components of the propositions matched would be considered the extent to which the input proposition is accurate. Above the input proposition does not match on one concept -- 1495 -- with the stored proposition.

Judging the value of an input concept or proposition is a slightly different process. To explain the process, we must expand our model of information storage a bit. Thus far we have stated that the mind stores semantic information as sets of interconnected propositions and concepts. Now let us assume that each concept, proposition or proposition set may have a value weight attached to it -- good, neutral or bad. Judging the value of an input concept or proposition would be identifying the value weight you have attached to your representation of the input concept or proposition. For example, someone says to you: "We will have two inches of snow tomorrow." To evaluate the value of this proposition, you would first search for your copy or representation of the proposition and then recall the value weight you have associated with it.

As the explanations of generalizing and evaluating illustrate the semantic model of cognition presented here can be used to explain and demonstrate mental processes otherwise very difficult to exemplify. Some of the basic input, organizational and output processes are formally taught in the schools (eg. reading and writing). However, the majority are not, and some are not even identified (eg. the content specific input and output processes).

A HIERARCHY OF THINKING SKILLS

We can combine the various characteristics of the model of semantic information processing into a hierarchy of thinking skills. I do this with many reservations about hierarchies. The extent to which any hierarchy of skills represents discrete activities is probably the extent to which that hierarchy is invalid. Any hierarchy of thinking skills defines and "trims" the component parts in such a way as to make them appear to be neatly organized in the fashion portrayed by the hierarchy. In reality, sets of skills usually interact in such a highly complex way as to be indefinable on one dimension. To this extent, any hierarchy of thinking is by definition invalid. However, as an organizational and instructional tool, hierarchies are quite useful. They give us a way to conceptualize and discuss interrelated pieces of information. Also, given our topic, a hierarchy would provide a useful tool around which to plan instruction. It is with the above qualifications and intent that the following hierarchy is presented.

1) Knowledge of the basic K-6 concepts

2) Knowledge of the different types of relationships between propositions

3) Knowledge of the different relationship patterns for proposition sets

4) Knowledge of the general input processes

5) Knowledge of the organizational processes

6) Knowledge of the general output processes

7) Knowledge of the content specific input processes

8) Knowledge of the content specific output processes

9) Knowledge of content specific concepts

10) Knowledge of content specific proposition sets

INSTRUCTIONAL IMPLICATIONS

As mentioned previously, the model is presented here only in an overview fashion. A detailed description of the model along with the K-12 instructional techniques are presented in Basic Concepts and Higher Order Thinking Skills: A Linguistic Perspective. Here I will summarize some of the instructional implications of the model. The reader will note that I state these implications in the form of "shoulds." Of course, these statements are representative only of my thinking on the topic.

Concepts

Concepts should be formally taught and reinforced at all grade levels. The 430 basic concept clusters identified for this model can be used as a K-6 basic concept curriculum. Other concepts specific to content areas at higher grade levels should be identified and formally taught within those content areas.

Relationships and Patterns

The various types of relationships that can exist between propositions (eg. reference, time, cause) and their patterns (eg. concept, similarity, dissimilarity) should be formally taught in the elementary schools. Information within the various content areas should then be presented to students via these patterns to facilitate the processing of information for students.

Basic Processes

The basic input, organizational and output processes should be formally taught to students at the elementary school level. (Here I mean basic processes to be all those not specific to content areas.) These processes should be considered fundamental skills necessary for academic success.

Content Specific Processes

The content specific processes should be identified by individual content area teachers and formally taught by those teachers as part of their courses. As was mentioned previously, for the most part content area teachers are unaware of the processes they expect students to know. Again it is the bright students who identify these processes and succeed.

Teach Thinking Not Content

The general implication of this model is that thinking skills not content should be the focus of instruction within the classroom. That is, we as educators should be teaching students to process and use information rather than know specific pieces of information. This has some intuitive appeal. Few adults remember the facts they were taught at the primary level. However, the cognitive processes they indirectly learned in those primary grades serve them on a daily basis in the processing of information.

Finally, I should note that the whole area of instruction in basic concepts and thinking skills is in an embryonic state. The model presented here should be considered a starting place from which other more advanced models may be developed. Consequently, the reader is encouraged to adapt the model to fit individual needs and teaching styles.